

NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report
Watershed Management Research

April 1, 1967 - September 30, 1967

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PROJECT 1601 - WATER YIELD IMPROVEMENT

Watershed Calibration - Is it ever long enough?

It is generally agreed that 5 years ought to be about long enough for a classical paired watershed calibration period. After 5 years the August flows for contiguous watersheds 2 and 3 at Hubbard Brook had a calibration of

$$(WS\ 2) = 1.168 (WS\ 3) - 0.026 \text{ inches}$$

shown by the dots and the dashed line on Figure 1. Two more years passed before watershed 2 was treated, including 1964 in which flow was three times that of the highest flow of the other 6 years. A revised calibration (solid line) gave

$$(WS\ 2) = 1.615 (WS\ 3) - 0.060 \text{ inches}$$

a major change, weighted heavily by the 1964 data. The first year after watershed 2 was clearcut (1966) the flow on watershed 3 was twice that of 1964, the previous high. We are forced to greatly extrapolate our calibration curve to obtain an untreated predicted flow of 1.2 inches for WS 2. The older calibration would have given only 0.9 inches. Fortunately the difference pales into insignificance compared to the measured flow of 5.8 inches from the clearcut watershed 2.

Effect of Aspect on Snowmelt Runoff

Of the seven watersheds currently being gaged on the Hubbard Brook Experimental Forest, six have southerly aspects and the seventh faces nearly due north. Two water years of data now available from the north-facing watershed were recently compared with data from south-aspect watersheds.

As expected, the most striking difference occurred in timing of snowmelt runoff. Accumulated percent of streamflow for the 1967 snowmelt period is plotted in Figure 2 for north and south aspect watersheds and a south-aspect clearcut watershed. Total streamflow for this period was 17.22 inches from the north aspect, 17.13 inches from the south aspect, and 18.92 inches from the clearcut south aspect.

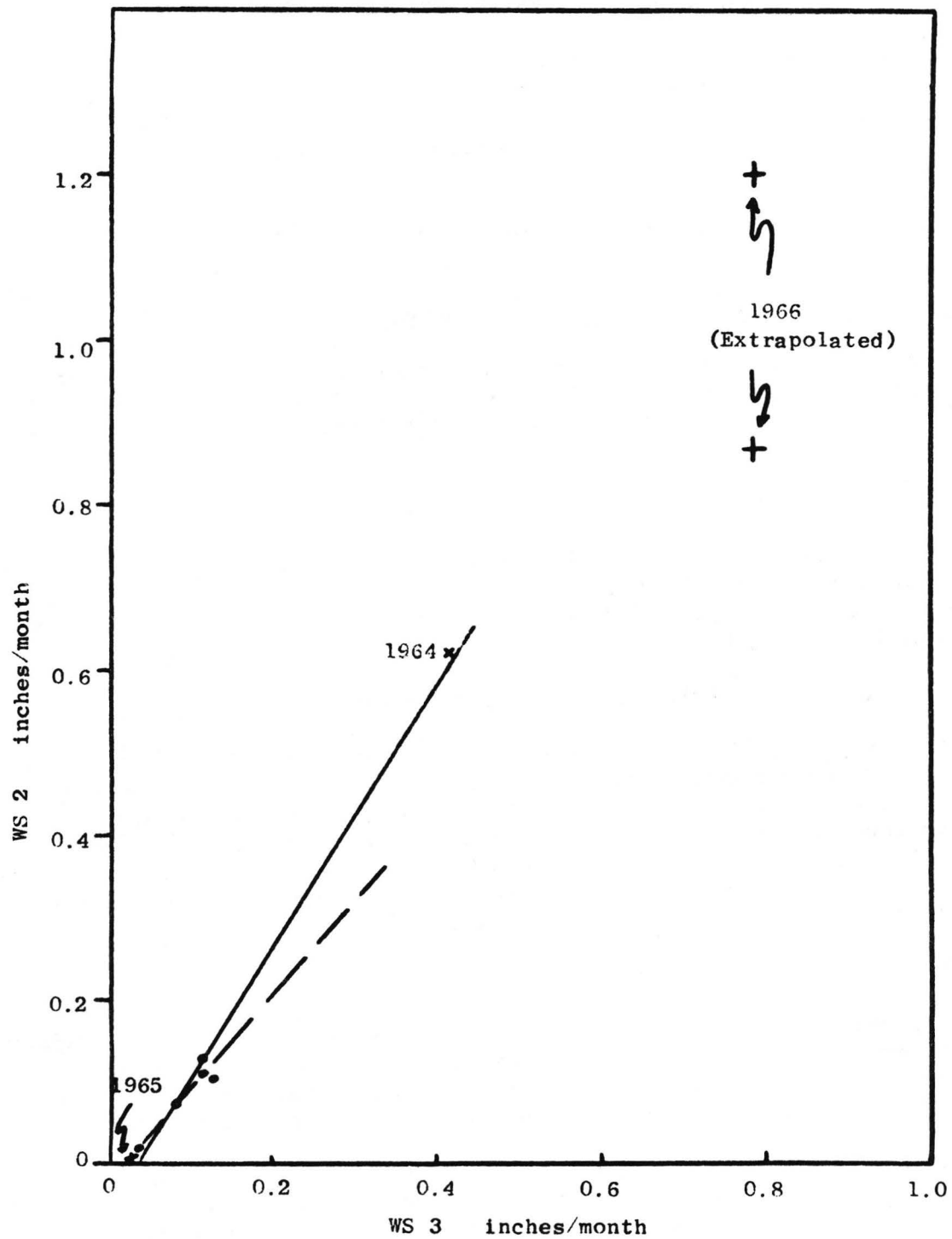


Fig. 1. 5- and 7-year calibration curves for August.

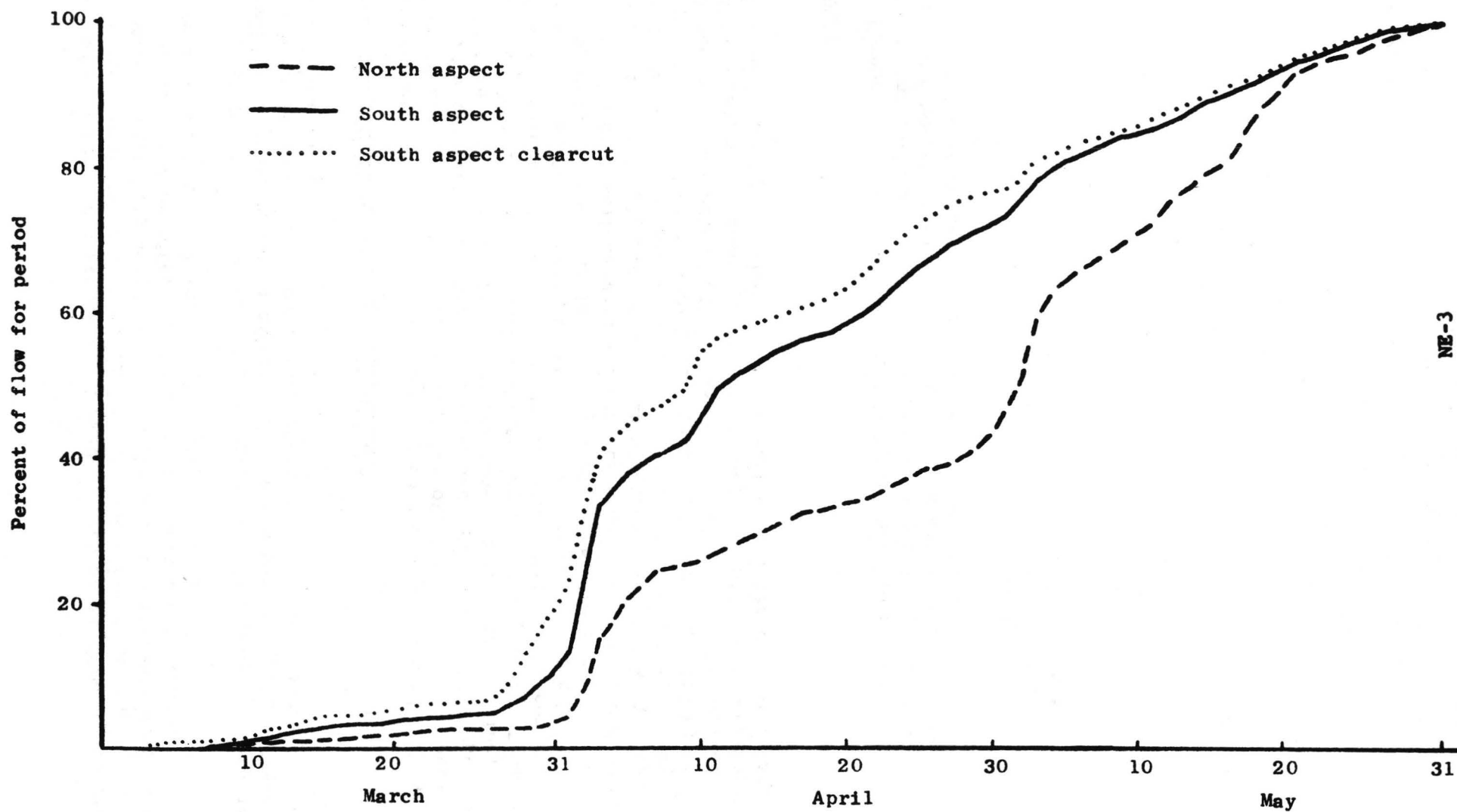


Fig. 2. Accumulated percent of streamflow for 1967 snowmelt period.

Streamflow from the north aspect lagged as much as 21 days behind the untreated south aspect. Clearcutting the south aspect advanced 1967 snowmelt runoff by 3 to 6 days. Thus the aspect difference appears to have a much greater effect on timing of snowmelt runoff than does a severe forest treatment on a south-facing watershed.

We are still faced with the question of what would happen to snowmelt timing on a clearcut north aspect. It would appear that the differences would not be as large as on south aspects because of the lesser influence of radiation.

Herbicide Treatments on Clearcut Watershed

The stubborn ability of plants to cling to a site is astounding. As reported earlier, a 25 lbs./A application of Bromacil via helicopter to a 39-acre clearcut watershed produced a strikingly favorable vegetation kill. The aim is to maintain a vegetation-free (non-transpiring) watershed for several years through a variety of climatic events. Bromacil virtually eliminated all small woody and herbaceous ground cover the first growing season after treatment. Some stumps sprouted but the leaves shriveled and discolored shortly after development. Although most of the soil surface remained bare of vegetation the second summer season, sprout growth from stumps was vigorous. An attack was made on these sprouts with a mist blower spray of 2,4,5-T in water. Heavy doses (4 gal. of 4 lbs. Acid Equivalent/100 gal. of water) applied to the foliage was required to kill the sprouts. In spite of the Bromacil and 2,4,5-T treatments, some sprouts and lesser vegetation were seemingly unharmed. Next spring there no doubt will be another crop of tenacious plants.

General

Jim Hornbeck, formerly at Parsons, West Virginia, joined our staff in June. Jim, filling a position left vacant since August of 1966, brings with him a wealth of experience under the tutelage of Ken Reinhart. We are fortunate in being able to lure Jim to New Hampshire.

-- R. S. Pierce
C. A. Federer
J. W. Hornbeck

PROJECT 1602 - FLOODS AND WATER YIELD

General

A new generation of watershed researchers is settling in at the Parsons Laboratory to carry on the work so ably headed by Ken Reinhart over the past 12 years. We inherit 9 gaged watersheds, an impressive publication record and, most important, a smoothly functioning support staff. Project leader Jim Patric, fresh from Alaska, is not new to watershed research in the Appalachians. Jim Kochenderfer, fresh from the Marlinton District of the Monongahela National Forest, is just starting his career in watershed research. A native of Parsons, he is a forestry graduate of the University of West Virginia with a master's degree from Duke. Chuck Troendle, a Syracuse man, is the old-timer of our staff, having been here 19 months. He has just completed stints of military and statistical training. Our recent arrivals have nothing to report at this time. Suffice it to say that they will build upon the existing foundation of Fernow studies in applying research findings to watershed problems over the northern Appalachian region.

Subsurface Flow

In addition to the loss and subsequent gain of both a project leader and a research forester we have completed the plans for a major subsurface flow study. We are now progressing with its installation and expect that the study "Subsurface flow on a steep forested slope" will be an aid to better understanding some of the basic characteristics of both storm and nonstorm moisture movement. We will use a 40 x 175 foot plot on a 35 percent slope. It will be instrumented to measure total outflow, moisture tension and content. An attempt will also be made to measure hydraulic conductivity at various points on the plot.

Some of the questions we wish to answer are: Through what horizons does the subsurface flow travel? How quickly does subsurface flow respond to precipitation? What is the duration and volume of flows between storm periods? How are outflow characteristics related to soil moisture patterns as estimated by tension and content measurements? What effect does antecedent moisture have on all these factors?

We anticipate that the study will be quite intensive and require much of this researcher's time during the next few years if we are to answer these questions. We feel the fruits will be worth the effort. The subject of subsurface moisture movement is not new to watershed research although citations in the literature on similar studies are not very numerous. Today much more emphasis is being placed on this aspect of research. We at Parsons would welcome any comments you may have on the subject.

Neutron-Meter Calibration

In addition, we have done some work in calibrating our neutron moisture meter this past summer. The only comment we have to make at this point is to ask a question: "Who has the neutron meter that goes with our factory calibration curve?"

---Charles A. Troendle

PROJECT 1603 - FOREST HYDROLOGY AND URBAN FOREST ENVIRONMENT

Our new and longer short project title replacing "watershed correlation and synthesis" denotes an additional objective: "to determine the nature and extent of the effects of urban and suburban trees and forest on human environment". To help us keep up with old and new responsibilities, Ken Reinhart, veteran watershed researcher of the Fernow, transferred to Upper Darby. We have half of Ken's time: the morning hours when he is fresh, eager, and full of wisdom. TMR has him after lunch.

Municipal Watersheds

Having difficulty deadening the woody vegetation on Newark No. 3 by injector techniques, Ed Corbett switched to an aerial application of herbicides. Previous injector applications of herbicides had left the watershed with a 30 percent cover of live overstory vegetation, a 10 percent cover of saplings, and a 26 percent ground cover of grass, herbaceous plants, and laurel at the end of 1966.

Keystone Helicopter Corporation of Philadelphia, using a Bell 47G-2A-1 helicopter, applied the chemical. The spray^{ing} consisted of 16 D-48 nozzles and was calibrated for an application rate of 23 gallons per minute. D-48 nozzles were used to produce large size spray droplets that reduced drift. The 2-ethylhexyl ester of 2,4,5-T was applied at the rate of 4 lbs. acid equivalent mixed with 3 gallons of water and 1 gallon of #2 fuel oil per acre. The boundaries of the watershed were marked with large fluorescent bags tied to the tops of trees.

Three months after spraying, top-kill indicated the overstory had been reduced to 3 percent cover, saplings to 3 percent cover, while ground cover (primarily grass and herbaceous plants) increased to 41 percent. The effects of this treatment on water yield will be evaluated at the completion of the recharge period.

To check on possible streamflow contamination, a series of water samples were collected in quart glass jars. Samples were taken from **both the treated** and adjacent control watersheds immediately after a flight swath up the stream channel (which was partially open to direct spraying), at the conclusion of the spray operation, and 1, 2, 4, 8, and 24 hours after completion of the spraying. Samples were also collected from the stream at a point one mile below Watershed No. 3. The sampling was repeated during and after the first substantial storm following the spray operation (a 3-inch storm two weeks after spraying). Samples were placed in an ice chest to retard chemical deterioration, taken to a commercial chemical laboratory, and analyzed for 2,4,5-T content by gas chromatography using electron capture techniques. All samples gave negative readings except the one taken immediately after the helicopter flew over the stream

channel. This sample contained 550 ppb of 2,4,5-T, the maximum instantaneous contamination in the stream which was flowing at only 0.058 cfs. Had the stream channel been covered by the original dense riparian vegetation or had we decided not to fly the strip over the channel, this contamination would have been much less. Later samples indicate that 2,4,5-T which is deposited on the forest vegetation or reaches the soil surface, is not washed into the stream channel by a large storm following a spray operation.

Regional Studies

Howard Lull, in the past 6 months, spent a few days in the Lake States with Roger Bay and Dick Sartz, went to Water for Peace, and participated in the 60th Anniversary Celebration of Penn State's School of Forest Resources. We pretty well wound up the Northeastern hardwood humus survey, and several weeks were spent looking for trends in long-time streamflow records from 23 watersheds. With Bill Sopper, we extended, in work plan, our study of streamflow characteristics of 137 small watersheds in the Northeast to 359 watersheds in the eastern forest region.

--H. W. Lull
E. S. Corbett
K. G. Reinhart

PROJECT 1604 - STREAM REGIMEN AND WATER YIELDS

The Cooperative Watershed Project at the College of Forestry received a large boost during the past six months by the addition of a Mobile Climatic Laboratory. This 20-foot trailer has been equipped with three electronic racks and a 5-channel tape recorder, as well as various strip-chart recorders. At the present time, this mobile unit is located at a field site about 20 miles north of Syracuse as a part of a cooperative investigation in turbulent wind flow through a red pine canopy. The field lab will be brought back to Syracuse and refitted for snow interception studies early next month.

Solar radiation relationships

The investigation of spatial and temporal variation of albedo has been extended to include northern hardwoods. In March 1967, a tramway system similar to the one already in operation in a pine stand near Warrensburg, New York was set up in a northern hardwood stand near Syracuse. This tramway is 100 feet in length and 65 feet high.

Radiation data taken since March appear to indicate an albedo of around

0.115 to 0.125 during the early spring (April-May) leafless period. The albedo increased to around 0.160 during the June-September period when the canopy was in leaf.

Watershed Evaluation

All the analyses of annual, seasonal and periodic streamflow from the 114 square-mile Tuscarora Creek Watershed in southwestern New York show essentially similar results. The expected primary dependence of streamflow on the climatological parameters, current and antecedent precipitation and temperature, is readily apparent in all cases. No time trend has been shown by any of the analyses which might be related to changes in land use or vegetative cover. The relatively minor changes in area of the forest stands over the period for which the streamflow record is available and the practice of continuous cutting may be in part the reason for the failure in this respect. Apparently any change in total volume or regimen of streamflow which may have occurred took place before the start of streamgaging. In the 27-year period studied, hydrologic conditions on the area have remained relatively stable.

Any additional studies designed to show the relationship between streamflow changes and land use on the Allegheny Plateau should begin earlier than 1938; probably in the first or second decade of the twentieth century.

Three Rivers Study Area

In conjunction with the College of Forestry, a micro-meteorological study area has been selected on the outskirts of Syracuse. The area includes two adjacent 40-year-old pine plantations, each about 10 acres in size, located on land owned by the State of New York. Fetch of the study area is around 1500 feet.

Major emphasis in this location will be on investigation of momentum exchange between and within the various segments of the canopy.

Accomplishments to date include the construction of a 60-foot-high scaffold tower. This installation is fully wired with 10 junction terminal boxes at five levels on the tower. All terminal boxes can be quickly plugged into the Mobile Climatic Laboratory.

--R. E. Leonard

PROJECT 1605 - FOREST RESTORATION OF STRIP MINED LANDS

General

Personnel from the Berea Research Center participated in a Strip-Mine Symposium at Owensboro, Kentucky on July 12, 13 and 14. Director Lane explained our project's research program, and Bill Plass, Willie Curtis, Perry Williams and Grant Davis each presented papers.

All Watershed Research personnel spent the week of August 21 - 25 touring Pennsylvania bituminous coal fields. Scientists from the Berea and Kingston centers explained their specialties at the annual meeting of the Research Committee on Coal Mine Spoil Revegetation in Pennsylvania. This committee helps plan and fund our research program in Pennsylvania.

The Kentucky Strip-Mine Research Coordinating Committee met in Berea on September 7. This committee is composed of state, federal and industry personnel and offers counsel on our research program.

On September 21, Dick Lane, Warren Doolittle, and Grant Davis met with state and industry personnel in Charleston, West Virginia in an attempt to initiate a cooperative research program in West Virginia similar to those in Pennsylvania and Kentucky.

--Grant Davis

Hydrology

Since the last report we have pre-cast enough concrete blocks for 13 broad-crested weirs. These are not box-type weirs, but rather cutoff wall type structures with 3:1 side slopes. A special acid resistant cement is being used for the blocks. Quality control has been quite good and we expect one rating will suffice for all weirs.

Three of the weirs have already been installed in the Leatherwood Watershed at an estimated cost of \$300 each--not including the water level recorder. Manpower amounts to about 10 man-days per weir--from start to finish. The next phase will be to rate the weirs over a wide range in flow depths.

Strip-mining began in one of the sub-drainages on August 15 and has, as of September 20, progressed about one-fourth the way around the watershed perimeter. We have had only small storms, so have noted no change of quality of water at the weir site.

--Willie R. Curtis

Earth Movement

A study to determine the factors which are related to the frequency and severity of land slide type disturbances on strip-mine spoil bank out-slopes is being planned. This study will be carried out with the cooperation of the Kentucky State Division of Stripmine Reclamation. Work is aimed at finding the major causes of the slides and at determining how these causes work in triggering the downslope spoil movement.

--George P. Williams

Revegetation

Because strip-mine spoils are low in plant available nitrogen, the nitrogen fixing ability of legumes makes this group of plants of special interest in spoil revegetation. However, in the eastern United States many spoils are acid, and because of the acidity plant toxic concentrations of manganese and aluminum are brought into solution. In one of our studies known symptoms of manganese toxicity were produced on legume seedlings by adding excess manganese to nutrient solutions. On all the legumes studied--Korean lespedeza, Kobe lespedeza, sericea lespedeza, bicolor lespedeza, birdsfoot trefoil and black locust--manganese toxicity was expressed by chlorosis on leaf margins. This chlorosis can be readily discerned on young leaves of all the above species except Kobe lespedeza.

The legumes mentioned above were also grown in the greenhouse on 46 Kentucky spoils. Korean and bicolor lespedeza usually had symptoms of manganese toxicity when grown on spoils with pH's below 5.0. Sericea lespedeza in the seedling stage was also susceptible but on some spoils it grew out of the toxicity symptoms. Kobe lespedeza, birdsfoot trefoil and black locust had no symptoms of manganese toxicity when grown on most of the spoils with pH above 4.5.

Water soluble and exchangeable manganese were determined on the spoils, but neither was reliable for predicting manganese toxicity on the legumes. Nodulation was good on legumes grown on spoils with pH's above 5.0, nodulation was nil or poor at pH's below 4.5. In the pH range 4.5 to 5.0 legume nodulation was good on some spoils but poor or absent on others.

Some additional greenhouse studies were made to compare growth of several grasses in spoils ranging in pH from 4.0 to 5.5. Analyses were made of the spoils for water soluble and 1 N KCL extractable calcium, magnesium, manganese, and aluminum. There was no direct correlation between base saturation of the spoils and grass yields nor between aluminum or manganese content and grass yields. In general, pH is still the best indicator of plant growth on acid spoils. Cool season grasses like K-31 tall fescue, orchard grass, ryegrass, and redtop did not grow well in the spoils with pH below 4.5. However, weeping lovegrass grew as well at pH 4.0 as it did at higher pH's.

--William A. Berg
Willis G. Vogel

PROJECT 1606 - MANAGEMENT OF STORM RUNOFF

Meetings

The past 6 months have flown, for much of the time was spent in planning a technical 6½ week European itinerary, changing and rechanging dates and places to allow for conflicts, sweating out overall approval, sweating out a Russian visa, and then finally making the trip.

This is being written just a few days after leaving Europe and I haven't had time to unscramble my notes, thoughts, or luggage. It's reminiscent of the housewife who has spent days planning Thanksgiving dinner and long hours preparing it. After a pleasant two-hour dinner and the gracious participants have departed, she returns to the reality of a kitchen stacked high with used pans and dishes. But the memory lingers on. And the Leningrad Flood Symposium was a meeting to remember. One hundred scientific papers were presented by people from 33 countries. In all 47 countries were represented, 6 international organizations cooperated, and about 250 people attended. The meeting was held in the Palace of Education (the site of Rasputin's demise). The Soviets have not yet invented ventilation, but if they ever do, I recommend it be installed in the Palace.

Overall the meeting was well conducted and quite interesting. Most of the papers were good--and sometimes the discussions were rather lively. (I think the usual way of putting it--"Our talks were quite useful and have opened the door to future discussions," could apply here.) I was a little surprised and very relieved that at no time did any mention of politics come up at the meeting or on the scientific excursions.

More about the entire trip in a later report; however, a few quick thoughts:

- a. Leningrad was a far more interesting city to me than Moscow--3-3/4 million people, built on 101 islands spanned by over 660 bridges. One can almost sense the blood and sweat that went into its history.
- b. The country between the Gulf of Finland and Moscow (900 km), flat to rolling, not too well drained, and covered extensively with good Scots pine and hardwood forests.
- c. Most of the towns and villages between Leningrad and Moscow built of sturdy-looking log cabins, small garden patches, dirt roads, and not much else.
- d. A good scientific atmosphere and plenty of opportunity to discuss research with the Russian engineers--once a side meeting was set up in advance. Few chances for impromptu discussions.
- e. Overall very interesting but the frustrations of trying to do some simple, everyday things sometimes shook the westerners to the quick.

Subsurface stormflow studies

The past 6 months were spent in revamping our plot system, trying out new run techniques, and in tree root research. (Aubertin's findings on a field study into root occurrence and pattern follow this.) We have long been interested in learning which parts of a specific watershed contribute most heavily to subsurface storm runoff and have felt that subsurface stormflow may be caused somewhat by a phenomenon analagous to the pressure wave concept in fluid mechanics or the generation of a sound or acoustical wave in aerodynamics. Here the velocity or celerity in feet/second would be expressed as $V = \sqrt{E/P}$ where V = velocity, E is bulk modulus of elasticity, and P is mass density. Some engineers do not believe this but it seems logical, and I feel it may be possible to study with tracers.

Our current summer studies are showing that by partially wetting portions of a hillside plot, rather quick flow does take place through the unwetted portion. For example, we have wet the upper 20 feet of a 60-foot long silt loam plot and tracked the time taken for flow to occur through the moist but unsprinkled lower 40 feet. The flow in all cases started in less than 2 hours. We are now wetting a 60-foot section of a deep sandy loam above the silt loam to study whether flow from this occurs during the storm period--or as baseflow. From a watershed standpoint we are also investigating the sources of flow from an elevation basis--specific areas across the contour appear to have concentrations of flow while other points at the same elevation and slope show little of the quick storm interflow.

--R. Z. Whipkey

Forest Soils Research--Literature Review

Correspondence with various institutions and researchers continued in an attempt to obtain as much root research literature information as possible. To date over 3,000 titles and references pertaining to various phases of roots and root channels have come to light. Unfortunately (or perhaps fortunately), many of these references are in obscure foreign publications and consequently not available for review. All in all, this has developed into a monumental task.

Hydraulic conductivity

Additional 6-inch diameter undisturbed soil cores were obtained from the periphery area surrounding the root study block. Hydraulic conductivity information was obtained from these cores via the established procedures previously reported. Upon termination of the hydraulic conductivity determinations the cores were systematically dissected and the pertinent features such as roots, stones, root channels and other macro passageways were noted and recorded. Special attention was directed to the existence of old root channels, cracks and macro-organism pathways in an attempt

to correlate their presence with the hydraulic conductivity value obtained for each given core. In addition, volume and weight measurements were made on the core and the root and stone fractions for future comparative volume percentage information. Due to the press of field work, the data have not as yet been completely calculated and analyzed. Therefore, no conclusions can be presented at this time.

Roots - Root channel research

This spring a large, free-standing block of soil, 8-feet wide by 20-feet long by 6-feet deep was exposed by trenching around the four sides with a backhoe. This block corresponded to the lower part of the active portion of a previous subsurface stormflow plot. The downslope face of the block was coincident with the outflow face of the former plot. After trimming and shaping the block by hand, all four sides were characterized, sampled, and the soil horizons mapped to scale. All major features such as roots, stones, old empty root channels, old filled root channels, filled and unfilled animal burrows, evidence of tap roots, worm and other macro-organism passageways, and structural cracks were mapped to scale for the front, back and one side. Unfortunately, due to the wet weather, a portion of one side sloughed down before its features could be mapped. After mapping the external features, the front or downslope portion of the block was systematically dissected by carefully removing 15 x 15 x 15 cm cubes of soil one at a time. All major internal features, as listed above for the external faces, were carefully traced and mapped on three-dimensional drawings.

The soil horizons "plots" were assembled into a scale "box" model of the block. This proved very interesting, especially in the extent of variation of the different horizons from point to point. It was not uncommon for different horizons, especially in the C horizon, to thin out and disappear only to reappear further along the face or on a different face. Although the upper horizons varied in thickness from point to point, the degree to which the A and B horizons paralleled the surface slope was quite surprising. Mechanical analysis indicated that the top 9 to 10 inches was a silt loam for all sides. But, below 10 inches the textural class for a given horizon often varied all the way from a silty clay loam to a silty clay to a clay, although the percents of sand, silt and clay were fairly similar.

The exterior "plots" were assembled into a scaled map of each face. These assembled "plots" contain a wealth of information. For example, there is considerable evidence of stratification of old root channels and live roots, which suggests that a tree species different from that now growing on the site formed the old root channels. Another very common feature found is live roots growing within old root channels. Although numerous roots and root channels were found clear down to the bottom of the block, most roots and root channels were found in the upper 2 to 2½ feet. In the lower depths of the C horizon most of the roots and root channels were restricted to structural cracks, while in

the A and B horizons or the upper $2\frac{1}{2}$ feet the roots and root channels freely permeated the soil mass. In the A and B horizons it was not at all uncommon to find 10 to 15 old root channels in each 15 x 15 cm surface area. The area occupied by these root channels ranged all the way from 1 or 2 percent up to about 75 or 80 percent. Quite generally there were considerably more live roots than old channels in these squares, but their larger number was compensated by their smaller size and consequently the percentage of the surface area occupied by live roots was considerably smaller than that for the old channels. Also, there were relatively few live roots which had diameters approaching the diameter of the old root channels. This leads to considerable speculation as to the persistence of the old root channels, many of which still retain a root bark lining, their rate and time of formation and by what species.

The three-dimensional diagrams of the dissected faces have not been studied as yet. Some general working observations indicate that the number and ramification of roots and old root channels are much greater than expected. Some cubes will no doubt contain 50 to 75 percent of their total volume as old channels, while many of the cubes in the A and B horizons will no doubt contain 20 to 30 percent of the total volume as live roots. It is very interesting to note how new roots follow the path of an old root. Many cases have been observed where a partially filled root channel is present in a much older filled root channel, while a new live root is found in the partially filled channel.

The data obtained to date have not been examined sufficiently to draw any conclusions. It is clear, however, that this procedure is much more time consuming than had been expected. Also, attempts to utilize such a large block are questionable. It is probable that considerably smaller blocks would give an adequate representation of the roots, root channels, and other features of a site.

--G. M. Aubertin

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Nitrification after Clearcutting a Forest Ecosystem. Bormann, Pierce, et al.

Hydrology of Contour-Stripped Land. Willie R. Curtis.

Revegetation. Grant Davis.

Spatial variation of Net Radiation, Albedo and Surface Temperature of Forest. C. A. Federer.

Rate of Chemical Weathering of Silicate Minerals in New Hampshire. Johnson, Likens, and Pierce.

A Treetop Tramway System for Meteorological Studies. R. E. Leonard and A. R. Eschner.

Albedo of Intercepted Snow. R. E. Leonard and A. R. Eschner.

Depth, Weight, and Water Storage of the Forest Floor in White Pine Stands in Massachusetts. Donald L. Mader and Howard W. Lull.

Strip-Mine Survey of Eastern Kentucky. William T. Plass.

Roads, Slides and Check Dams. George P. Williams, Jr.